September 7, 2011 Physics 121 Prof. E. F. Redish

- **Theme Music: Wynton Marsalis**
  ***Where or When?***
- **Cartoon: Jim Davis**
  ***Garfield***


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# Useful numbers (people)

| *Numbers* | |
|---|---|
| Number of people on the earth | ~7 billion ($7 \times 10^9$) |
| Number of people in the USA | ~ 300 million ($3 \times 10^8$) |
| Number of people in the state of Maryland | ~ 5 million ($5 \times 10^6$) |
| Number of students in a large state university | ~30-40 thousand ($3 \times 10^4$) |

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# Useful numbers (distances)

| *Macro Distances* | |
|---|---|
| Circumference of the earth | ~24,000 miles (1000 miles/ time zone at the equator) |
| Radius of the earth* | $2/\pi \times 10^7$ m |
| Distance across the USA | ~3000 miles |
| Distance across DC | ~10 miles |



# Useful numbers (bio)

| *Bio Scales* | |
|---|---|
| Size of a typical animal cell | ~10-20 microns ($10^{-5}$ m) |
| Size of a bacterium, chloroplast, or mitochondrion | ~1 micron ($10^{-6}$ m) |
| Size of a medium-sized virus | ~0.1 micron ($10^{-7}$ m) |
| Thickness of a cell membrane | ~5-10 nm ($10^{-8}$ m) |

# Foothold ideas

- We may choose to use an idea for a while – as a "foothold," to see how it works, and perhaps reject it later in favor of a replacement or refinement.
- These ideas become the basic principles we will use to reason – the "stakes in the ground" of our safety net.

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# Foothold ideas: Dimensions and units

- Each measurement is a counting of something. It matters what kind of thing we are counting.
- The kind of counting we are doing is expressed in terms of basic types: dimensions (M, L, T).
- Only measurements of the same dimensionality can be added or equated since the dimensionality tells how the measurement changes when the scale is changed. (cf., length [L], area [$L^2$], volume [$L^3$])
- The specific scale chosen for a measurement is the unit.

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# Cat television

- When we do science, we don't try to solve the entire universe at once.
- We restrict our considerations to a limited set of data and try to understand it. Only when we get it do we try to expand further to more situations.
- This is like looking out a window onto a small segment of the world. Since cats like to do this, I call the process "choosing a channel on cat television."

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# The Main Question

*(for this term, at least)*

- Start by choosing a big question and then refining it:

***<u>How do things move?</u>***

**Why choose this?**

- **–concepts of measurement, rate of change force are fundamental**
- **–ties to everyday experience so can use and learn to build/refine intuition**

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# Describing Motion: Space

- Coordinates — telling where something is
- What do we need to do to specify
  the location of something
  so someone else can find it?
  - Note the difference between "length" or "distance" and "position"
  - Representing a position mathematically.



# Motion along a straight line (1-dimensional coordinates)

- We specify which direction we are talking about by drawing a little arrow of unit length in the positive direction.
- We specify that we are talking about this arrow in symbols by writing $\hat{i}$
- A position a distance $x$ from the origin is written $\vec{r} = x\hat{i}$
- Note that if $x$ is negative, it means a vector pointing in the direction opposite to $\hat{i}$

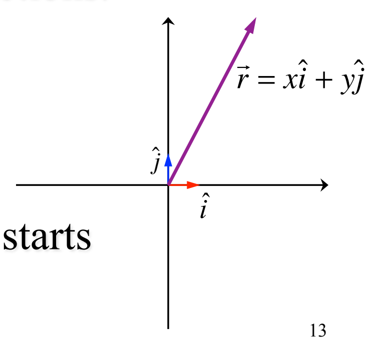
# Coordinates and Vectors

- Set up a coordinate system
  - Pick an origin
  - Pick perpendicular directions
  - Choose a measurement scale
- Each point in space in then specified by three numbers: the *x*, *y*, and *z* coordinates.
- The position vector for a particular position is an arrow drawn from the origin to that position.



# Motion in a plane (2-dimensional coordinates)

- We specify the directions we are talking about by drawing two little arrows of unit length in two perpendicular directions.
- "*x*" and "*y*" are called the coordinates and can be positive or negative.
- A position vector always starts from the origin.



# Describing Motion: Time

- Time — if we're to describe something moving we need to tell <u>when</u> it is where it is.
- Time is a coordinate just like position
  - We need an origin (when we choose $t = 0$)
  - a direction (usually times later than 0 are +)
  - a scale (seconds, years, millennia)
- Note the difference between
  - clock reading, $t$
  - a time interval, $\Delta t$

**This is like the difference between position and length!**



# Graphing Position

- Graphs for the eye vs. graphs for the mind.
- Describe where something is in terms of its coordinate at a given time.

  - Choose origin
  - Choose axes
  - Choose scale
  - Set scales on graph
  - Take data from video
  - Construct different graphs
  - Fit the graphs with math functions